Please type a plus sign (+) inside this box → [+]

PTO/SB/05 (2/98)
Approved for use through 09/30/2000. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 C.F.R. § 1.53(b))

Attorney Docket No.	XA-8993
First Inventor or Application Identifier	Yasunobu FUJITA
Title	ROLLER BEARING
Express Mail Label No.	

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231

1. [X] * Fee Transmittal Form *(e.g., PTO/SB/17)* *(Submit an original and a duplicate for fee processing)*
2. [X] Specification [Total Pages 21] *(preferred arrangement set forth below)*
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [X] Drawing(s) *(35 U.S.C. 113)* [Total Sheets 1]
4. Oath or Declaration [Total Pages]
   a. [ ] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 C.F.R. § 1.63(d)) *(for continuation/divisional with Box 17 completed)* *[Note Box 5 below]*
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).
5. [ ] Incorporation By Reference *(useable if Box 4b is checked)* The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered to be part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. [ ] Microfiche Computer Program *(Appendix)*
7. Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all necessary)*
   a. [ ] Computer Readable Copy
   b. [ ] Paper Copy (identical to computer copy)
   c. [ ] Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. [ ] Assignment Papers (cover sheet & document(s))
9. [ ] 37 C.F.R.§3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
10. [ ] English Translation Document *(if applicable)*
11. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
12. [ ] Preliminary Amendment
13. [X] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
14. [ ] * Small Entity Statement(s) *(PTO/SB/09-12)* [ ] Statement filed in prior application, Status still proper and desired
15. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
16. [X] Other: additional information sheet

*NOTE FOR ITEMS 1 & 14: IN ORDER TO BE ENTITLED TO PAY SMALL ENTITY FEES, A SMALL ENTITY STATEMENT IS REQUIRED (37 C.F.R. § 1.27), EXCEPT IF ONE FILED IN A PRIOR APPLICATION IS RELIED UPON (37 C.F.R. § 1.28).

17. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in a preliminary amendment:*
[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No: ____/____
Prior application information: Examiner ____ *Group / Art Unit:* ____

18. CORRESPONDENCE ADDRESS

[ ] *Customer Number or Bar Code Label* *(Insert Customer No. or Attach bar code label here)* or [X] *Correspondence address below*

Name	Mitchell W. Shapiro Vorys, Sater, Seymour and Pease LLP				
Address	1828 L Street, N.W. Eleventh Floor				
City	Washington	State	DC	Zip Code	20036-5109
Country	USA	Telephone	(202)467-8812	Fax	(202) 467-8900

Name (Print/Type)	Mitchell W. Shapiro	Registration No. (Attorney/Agent)	31,568
Signature	Mitchell W. Shapiro	Date	11/25/98

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Box Patent Application, Washington, DC 20231.

Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

FEE TRANSMITTAL

Patent fees are subject to annual revision on October 1. These are the fees effective October 1, 1997. Small Entity payments must be supported by a small entity statement, otherwise large entity fees must be paid. See Forms PTO/SB/09-12. See 37 C.F.R. §§ 1.27 and 1.28.

TOTAL AMOUNT OF PAYMENT ($) 760.00

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	Yasunobu FUJITA
Examiner Name	
Group / Art Unit	
Attorney Docket No.	

METHOD OF PAYMENT (check one)

1. [X] The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:

Deposit Account Number: 22-0585

Deposit Account Name: Vorys, Sater et al.

[X] Charge Any Additional Fee Required Under 37 C.F.R. §§ 1.16 and 1.17 [ ] Charge the Issue Fee Set in 37 C.F.R. § 1.18 at the Mailing of the Notice of Allowance

2. [X] Payment Enclosed: [X] Check [ ] Money Order [ ] Other

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	790	201	395	Utility filing fee	760.
106	330	206	165	Design filing fee	
107	540	207	270	Plant filing fee	
108	790	208	395	Reissue filing fee	
114	150	214	75	Provisional filing fee	

SUBTOTAL (1) ($) 760.00

2. EXTRA CLAIM FEES

	Extra Claims		Fee from below	Fee Paid
Total Claims	3 -20** =	0	X	= 0
Independent Claims	1 - 3** =	0	X	= 0
Multiple Dependent				=

**or number previously paid, if greater; For Reissues, see below

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	22	203	11	Claims in excess of 20
102	82	202	41	Independent claims in excess of 3
104	270	204	135	Multiple dependent claim, if not paid
109	82	209	41	** Reissue independent claims over original patent
110	22	210	11	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 0.00

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet.	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	400	216	200	Extension for reply within second month	
117	950	217	475	Extension for reply within third month	
118	1,510	218	755	Extension for reply within fourth month	
128	2,060	228	1,030	Extension for reply within fifth month	
119	310	219	155	Notice of Appeal	
120	310	220	155	Filing a brief in support of an appeal	
121	270	221	135	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,320	241	660	Petition to revive - unintentional	
142	1,320	242	660	Utility issue fee (or reissue)	
143	450	243	225	Design issue fee	
144	670	244	335	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	790	246	395	Filing a submission after final rejection (37 CFR 1.129(a))	
149	790	249	395	For each additional invention to be examined (37 CFR 1.129(b))	

Other fee (specify) _____

Other fee (specify) _____

* Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 0.00

SUBMITTED BY				Complete (if applicable)	
Typed or Printed Name	Mitchell W. Shapiro			Reg. Number	31,568
Signature	Mitchell W. Shapiro	Date	11/25/98	Deposit Account User ID	

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

ADDITIONAL INFORMATION SHEET FOR NEW PATENT APPLICATION

INVENTORS:

Inventor: Yasunobu FUJITA
Residence: Kanagawa-ken, JAPAN

Inventor: Keisuke KIMURA
Residence: Kanagawa-ken, JAPAN

Inventor: Michiharu NAKA
Residence: Kanagawa-ken, JAPAN

PRIORITY INFORMATION:

A certified copy of Japanese Patent Application Nos. 9-324446 filed November 26, 1997 and 10-332635 filed November 24, 1998 will follow, for which Applicants claim priority under 35 U.S.C. § 119.

ROLLER BEARING

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a roller bearing, and particularly to a roller bearing in a bearing for a spindle which is a portion of the constituent parts of various motors or the like and which is excellent in bearing characteristic and is greatly mitigated in fretting corrosion created by repeated shock and swing attributable to extraneous vibration as during conveyance.

Related Background Art

The industry related to electrical instruments is high in the speed of technological innovation as compared with the other industrial fields. The available periods of types of machines are short and moreover, new types of machines having introduced new techniques (smaller electric power consumption, higher responsiveness, higher accuracy, compactness, etc.) are developed one after another.

Now, the bearings for the spindles of various motors or the like have been made higher in speed with the development of the new types of machines as described above and lower torque has come to be required of them for the purpose of smaller electric power consumption. In the roller bearings used for the

spindles according to the prior art, there have been adopted a lubricating system filled with grease, and a method of applying lubricating oil to the raceway surface or the like of the bearing and further enclose grease therein. At present, for the purpose of lower torque resulting from the requirement for smaller electric power consumption as described above, an amount of grease is less, and as lubricating oil applied to the raceway surface or the like of the bearing, many lubricating oils of low dynamic viscosity (dynamic viscosity of 5 to 15 mm^2/s at 40°C) are used for rust prevention and in the low torque.

Now, the inland conveyance of various motors often takes place on land, and they are transported under environment apt to be subjected to extraneous vibrations. By these extraneous vibrations, the bearings for the spindles suffer from axial excitation, or repeated circumferential swing depending on the way in which the instruments are placed.

When such axial vibration or circumferential swinging movement is repeated, a bearing for a spindle directed to low torque may suffer from the possibility of creating fretting corrosion on the raceway surfaces of the outer race and inner race thereof and the contact surfaces of the rolling elements thereof because the quantity of grease is small and moreover the strength of oil film is low in lubricating oil of

low dynamic viscosity.

The creation of fretting corrosion may result in an increase in the sound and vibration of the bearing and may also pose a serious problem in a further improvement in required accuracy.

So, the present invention has been made in order to prevent the creation of fretting corrosion which may be created in a bearing for a spindle during the conveyance of various motors as noted above, and the object thereof is to provide a fretting-resisting roller bearing which is not adversely affected in its characteristics and achieves a higher temperature and a higher speed as well as a longer life.

SUMMARY OF THE INVENTION

To achieve the above object, the roller bearing of the present invention is a roller bearing comprised of a plurality of rolling elements held between an inner race and an outer race with a cage interposed therebetween, characterized in that the oil film of lubricating oil of which the dynamic viscosity at 40°C is 20 to 150 mm^2/s is formed on the raceway surfaces of the inner and outer races, the cage and the rolling elements and grease is enclosed.

The roller bearing of the present invention is heightened in the dynamic viscosity of the lubricating oil and the strength of the oil film with a view to

improve the fretting-resisting property during the conveyance of various motors.

Also, for example, the rolling elements are made of ceramics or a super-hard alloy of which the Vickers hardness is 1300 or greater, and the outer race and inner race are made of steel, and a material differing from that of the outer race and inner race is used as the material of the rolling elements and the hardness thereof is increased, whereby not only fretting corrosion can be suppressed by the prevention of the adhesion phenomenon between the members (the raceway surfaces of the outer and inner races and the rolling elements) and the decrease in Hertzian contact area due to the difference in Young's modulus, but also a good function is obtained even under use conditions of high temperature and high-speed rotation.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graph showing the acceleration signal execution values of each embodiment and each comparative example.

Fig. 2 is a graph showing the rotation torques of each embodiment and each comparative example.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Some embodiments of the fretting-resisting roller bearing of the present invention will

hereinafter be described in detail.

The fretting-resisting roller bearing of the present invention is a roller bearing comprised of a plurality of rolling elements held between an inner race and an outer race with a cage interposed therebetween, wherein the oil film of lubricating oil of which the dynamic viscosity at 40°C is 20 to 150 mm^2/s is formed on the raceway surfaces of the inner and outer races, the cage and the rolling elements, and grease is enclosed.

When the dynamic viscosity of the lubricating oil at 40°C is less than 20 mm^2/s, the strength of the oil film is low and fretting corrosion is liable to be created by extraneous vibrations. When conversely, the dynamic viscosity at 40°C is higher than 150 mm^2/s, rotation torque increases because the dynamic viscosity of the lubricating oil is high. Further, to reduce fretting corrosion, it is preferable that the dynamic viscosity at 40°C be 40 mm^2/s or greater.

While the lubricant composition used as the lubricating oil is not particularly limited, it may be composed of base oil and various additives mentioned below, whereby there is formed lubricating oil film having a fretting-resisting property and a rust prevention property and suitable for use at a high temperatures and high speeds. In the embodiments as described hereinafter, the composition of the additives

can be selected in accordance with using conditions of bearings if control of fretting corrosion is maintained and functions of anti-rust properties and additional properties can be combined in need. Particularly, if the higher anti-rust properties are required under some using conditions, preferably the lubricant oil may be anti-rust lubricant oil combined with the rust prevention agent, which has high anti-rust properties.

(Base Oil)

Regarding the base oil, as ester oil, use may preferably be made of diester oil obtained from the reaction of dibasic acid and branch alcohol, aromatic ester oil obtained from the reaction of aromatic tribasic acid and branch alcohol, or hindered ester oil obtained from the reaction of polyatomic alcohol and monobasic acid.

As diester oil, mention may be made of dioctyl adipate (DOA), diisobutyl adipate (DIBA), dibutyl adipate (DBA), dioctyl azelate (DOZ), dibutyl sebacate (DBA), dioctyl sebacate (DOS), methyl acetyl recinolate (MAR-N) or the like.

As aromatic ester oil, mention may be made of trimellitic acid ester, trioctyl trimellitate (TOTM), tridecyl trimellitate, tetraoctyl pyromellitate or the like.

As hindered ester oil, mention may be made of one obtained by polyatomic alcohol and monobasic acid shown

below being suitably reacted with each other. Monobasic acid to be reacted with polyatomic alcohol may be single or plural. Further, it may be used as complex ester which is oligoester of polyatomic alcohol and mixed aliphatic acid of dibasic acid and monobasic acid.

As polyatomic alcohol, mention may be made of trimethylol propane (TMP), pentaerythritol (PE), dipentaerythritol (DPE), neopentyl glycol (NPG), 2-methyl-2-propyl-1,3-propane (MPPD) or the like.

As monobasic acid, use is made chiefly of univalent aliphatic acid of C_4 to C_{18}. Specifically, mention may be made of acetic acid, valerianic acid, caproic acid, caprylic acid, enanthic acid, pelargonic acid, capric acid, undecanic acid, laurylic acid, mistiric acid, palmitic acid, beef fatty acid, stearic acid, caproleic acid, undecylenic acid, linder acid, tudu acid, fiseterinic acid, milistolenic acid, palmitoleic acid, petroserine acid, oleic acid, elaiolic acid, asclepic acid, vaccenic acid, sorbic acid, linoleic acid, linolenic acid, sabineic acid, recinoleic acid, or the like.

As synthetic hydrocarbon oil, there is phenyl ether oil in which (di)alkyl chain of C_{12} to C_{20} of disphenyl, tripheyl and tetraphenyl was derived.

Taking lower evaporation and longer life into account, it is preferable that ester oil be chosen from

aromatic ester oil and hindered ester oil and be used singly or mixedly. Particularly TOTM is readily available and is excellent in a low evaporating property, a lubricating property, etc. Also, (di)alkyl polyphenyl ether oil is preferable as ether oil. Fluorophosphazene oil can also be suitably used.

Also, by adding additives such as rust prevention agents, oily agents and oxidation preventing agents mentioned below, lubricating performance (fretting-resisting property or the like) and durable performance can be more improved.

(Rust prevention Agent)

Organic sulfonic acid metal or ester is preferable as a rust prevention agent. As organic sulfonic acid salt, use is made, for example, of dinonyl naphthalene sulfonic acid and heavy alkyl benzene sulfonic acid, and as the metal salt thereof, there is calcium sulfonate, barium sulfonate, sodium sulfonate or the like.

As ester, in sorbitan derivative, there is sorbitan monolaurate, sorbitan tristearate, sorbitan monooleate, sorbitan trioleate or the like as the partial ester of polybasic carboxylic acid and polyatomic alcohol. As alkyl ester type, there is polyoxyethylene laurate, polyoxyethylene oleate, polyoxyethylene stearate or the like.

As these rust prevention agents, organic sulfonic

acid metal salt and ester can be used singly or as a mixture. Taking it into account to improve the rust prevention property and suppress fretting corrosion, ester polyoxyethylene sorbitan laurate is high in dissolving property and is suitably used as sulfonic acid metallic salt such as calcium sulfonate, and fluorophosphazene oil.

(Oily Agent)

As an oil agent, oleic acid, stearic acid or the like as higher fatty acid, lauryl alcohol, oleyl alcohol or the like as higher alcohol, stearyl amine, cetyl amine or the like as amine - these can be used singly or mixedly.

(Oxidation Preventing Agent)

As an oxidation preventing agent, a nitrogen containing compound oxidation preventing agent and a phenol oxidation preventing agent may preferably be used singly or as a mixture.

As the nitrogen containing compound oxidation preventing agent, there is phenyl α naphthylamine, diphenylamine, phenylene diamine, oleyl amideamine, phenothiazine or the like.

As a phenol oxidation preventing agent, there is hindered phenol such as p-t-butyl-phenyl salicylate, 2,6-di-t-butyl-p-phenyl phenol, 2,2'-methylenebis-(4-methyl-6-t-octyl phenol), 4,4'-butyrydenbis-6-t-butyl-m-cresol, tetrakis[methylene-3-(3',5'-di-t-butyl-

4'-hydroxyphenyl)propionate]methane, 1,3,5-trimethyl-2,4,6-tris(3,5-di-t-butyl-4-hydroxylbenzil)benzene, n-octadecyl-β-(4'-hydroxy-3',5'-di-t-butylphenyl)propionate, 2-n-octylthio-4,6-di(4'-hydroxy-3',5'-di-t-butyl)phenoxy-1,3,5-triazine, 4,4'-thiobisu-[6-t-butyl-m-cresol], 2-(2'-hydroxy-3'-t-butyl-5'-methylphenyl)-5-chlorobenzotriazole or the like.

(Extreme Pressure Agent)

As an extreme pressure agent, use can be made of organic metallic salt such as molybdenum thiocarbamate, molybdenum dithio phosphate, zinc diocarbamate, zinc dithiophosphate or the like.

(Corrosion Preventing Agent)

As a corrosion preventing agent, mention may be made of phosphoric acid ester, phosphorous acid ester or the like. Particularly, molybdenum dithiocarbamate and phosphorous acid ester exhibit an excellent effect in the fretting resisting property and can therefore be suitably used.

In addition to the foregoing agents, a friction preventing agent, a viscosity index improving agent or the like may be contained in the lubricating oil. These may all be conventional agents.

Regarding the base oil and additive of the grease enclosed in the above-described fretting-resisting roller bearing of the present invention, use may be

made of ones similar to the above-described lubricating oil composition of the present invention. Also, a thickness may be a conventional one such as metallic soap or urea resin, but from the viewpoint of the characteristic of the bearing for a spindle, lithium soap having an excellent characteristic in acoustic life is preferable.

In the case of the fretting-resisting roller bearing of the present invention, the contacting portions of the raceway surfaces of the outer and inner races and the rolling elements are the same material or different materials, and when different materials are used, they are steel and ceramics or steel and a super-hard alloy. If the lubricating oil in the present invention is used, the fretting corrosion will be greatly mitigated, and further, under an environment of severe vibration condition, different materials may be small in the frictional force acting on the contacting portions as compared with steel and steel, and in these contacting portions, it is more difficult for such an injury which will lead to fretting corrosion to occur.

In the case of ceramics, the material forming the rolling elements may be silicon nitride, zirconia, alumina or the like, and in the case of a super-high alloy, the material forming the rolling elements may be tungsten carbide or the like.

The friction characteristic on the contacting

portions of the raceways of the outer and inner races made of steel and the rolling surfaces of the rolling elements made of ceramics or a super-hard alloy is improved as compared with the friction characteristic when steel and steel contact with each other, even if the combination of different materials is steel and ceramics or steel and a super-hard alloy. Above all, the combination of bearing steel and silicon nitride, stainless steel and silicon nitride, bearing steel and zirconia, bearing steel and tungsten carbamate, or stainless steel and tungsten carbamate provides an excellent friction characteristic (a low friction characteristic) and is excellent in the fretting resisting property. By combining these with the above-mentioned lubricating oil, a further effect is obtained against fretting corrosion and these combinations can be preferably be used.

Description will now be made of the conditions and results of evaluation tests carried out to confirm the effect of the present invention.

[Bearing Outer Race Swing Test]

Tested bearing	:	695
Frequency	:	27 Hz
Angle of swing	:	2°
Load (Fa)	:	14.7 N
Frequency of swing	:	1×10^5 times
Enclosed grease	:	Lithium soap grease

The above-mentioned swing test was carried out, and the acceleration of the bearing in the radial direction thereof after the test was measured and evaluation was effected.

A heretofore used bearing specification [Comparative Example 1] was subjected to a swing test, and comparison evaluation was effected with the bearing radial direction acceleration signal execution value after the test being 100%.

It is because the traces of minute fretting corrosion created on the inner and outer races and rolling elements of the bearing can be measured with good sensitivity that the bearing radial direction acceleration was used as a test evaluation item.

[Measurement of Rotation Torque]

Tested bearing	:	695
Load (Fa)	:	14.7 N
Number of revolutions	:	3600 rpm

As regards the magnitude of torque, 1.2 gf·cm or less was regarded as being successful.

The test conditions of each embodiment and each comparative example are as follows:

[Embodiment 1]

A bearing in which lubricating oil C of which the dynamic viscosity at 40°C was 90 mm^2/s was formed into film on the raceway surfaces of inner and outer races, a cage and rolling elements and grease was enclosed was

tested in a pre-load state under the above-mentioned conditions.

[Embodiment 2]

A bearing in which rolling elements were made of silicon nitride and lubricating oil C of which the dynamic viscosity at 40°C was 90 mm^2/s was formed into film on the raceway surfaces of inner and outer races, a cage and rolling elements and grease was enclosed was tested in a pre-load state under the above-mentioned conditions.

[Embodiment 3]

A bearing in which rolling elements were made of tungsten carbide of Vickers hardness 1300 and lubricating oil C of which the dynamic viscosity at 40°C was 90 mm^2/s was formed into film on the raceway surfaces of inner and outer races, a cage and rolling elements and grease was enclosed was tested in a pre-load state under the above-mentioned conditions.

[Embodiment 4]

A bearing in which lubricating oil B of which the dynamic viscosity at 40°C was 25 mm^2/s was formed into film on the raceway surfaces of inner and outer races, a cage and rolling elements and grease was enclosed was tested in a pre-load state under the above-mentioned conditions.

[Embodiment 5]

A bearing in which rolling elements were made of

silicon nitride and lubricating oil B of which the dynamic viscosity at 40°C was 25 mm^2/s was formed into film on the raceway surfaces of inner and outer races, a cage and rolling elements and grease was enclosed was tested in a pre-load state under the above-mentioned conditions.

[Embodiment 6]

A bearing in which rolling elements were made of tungsten carbide of Vickers hardness 1300 and lubricating oil B of which the dynamic viscosity at 40°C was 25 mm^2/s was formed into film on the raceway surfaces of inner and outer races, a cage and rolling elements and grease was enclosed was tested in a pre-load state under the above-mentioned conditions.

[Embodiment 7]

A bearing in which lubricating oil E of which the dynamic viscosity at 40°C was 150 mm^2/s was formed into film on the raceway surfaces of inner and outer races, a cage and rolling elements and grease was enclosed was tested in a pre-load state under the above-mentioned conditions.

[Embodiment 8]

A bearing in which lubricating oil F of which the dynamic viscosity at 40°C was 25 mm^2/s was formed into film on the raceway surfaces of inner and outer races, a cage and rolling elements and grease was enclosed was tested in a pre-load state under the

above-mentioned conditions.

[Embodiment 9]

A bearing in which lubricating oil G of which the dynamic viscosity at 40°C was 90 mm^2/s was formed into film on the raceway surfaces of inner and outer races, a cage and rolling elements and grease was enclosed was tested in a pre-load state under the above-mentioned conditions.

[Embodiment 10]

A bearing in which lubricating oil H of which the dynamic viscosity at 40°C was 120 mm^2/s was formed into film on the raceway surfaces of inner and outer races, a cage and rolling elements and grease was enclosed was tested in a pre-load state under the above-mentioned conditions.

[Comparative Example 1]

A bearing in which lubricating oil A of which the dynamic viscosity at 40°C was 11 mm^2/s was formed into film on the raceway surfaces of inner and outer races, a cage and rolling elements and grease was enclosed was tested in a pre-load state under the above-mentioned conditions.

[Comparative Example 2]

A bearing in which lubricating oil D of which the dynamic viscosity at 40°C was 160 mm^2/s was formed into film on the raceway surfaces of inner and outer races, a cage and rolling elements and grease was enclosed was

tested in a pre-load state under the above-mentioned conditions.

The compositions of the lubricating oils A to H used in the above-described embodiments and comparative examples are shown in Table 1 below.

Table 1

	Lubricating Oil A	Lubricating Oil B	Lubricating Oil C	Lubricating Oil D
kind of oil	DOS	PAO	TOTM	ADE
dynamic viscosity mm^2/s (40°C)	11	25	90	160
rust prevention agent	calcium sulfonate	calcium sulfonate	calcium sulfonate	sodium sulfonate
additive	-	zinc dithiophosphate	molybdenum dithiophosphate	phosphorous acid ester

Table 1 (continued)

	Lubricating Oil E	Lubricating Oil F	Lubricating Oil G	Lubricating Oil H
kind of oil	MO	PET	TOTM	PAO
dynamic viscosity mm^2/s (40°C)	150	25	90	120
rust prevention agent	sodium sulfonate	calcium sulfonate	barium sulfonate	calcium sulfonate
additive	phosphorous acid	phosphorous acid ester	zinc dithiophosphate	molybenum dithiophosphate

DOS : dioctyl sebacate,

PAO : poly-α-olefin,

TOTM : trioctyl trimellitate,

ADE : alkyl diphenyl ether

MO : mineral oil

The acceleration signal execution values and rotation torques in the above-described embodiments and comparative examples are shown in the graphs of Figs. 1 and 2, respectively.

According to the fretting-resisting roller bearing of the present invention described above, there are obtained the following effects:

(1) The oil film of lubricating oil having high dynamic viscosity is formed on the raceway surfaces of the inner and outer races, the cage and the rolling elements and therefore, there can be provided a

fretting-resisting roller bearing in which the strength of the oil film is high and the fretting-resisting property during conveyance is improved and also the various characteristics of the bearing are not adversely affected and which achieves a higher temperature and a higher speed as well as a longer life.

(2) When the material of the rolling elements is ceramics or a super-hard alloy of Vickers hardness 1300 or greater and the outer and inner races are made of steel and a material differing from the material of the outer and inner races is used as the material of the rolling elements, the hardness thereof is increased, whereby not only fretting corrosion can be suppressed by the prevention of the adhesion phenomenon between the members (the raceway surfaces of the outer and inner races and the rolling elements) and the decrease in the Hertzian contact area by the difference in Young's modulus, but also the bearing functions well even under the use conditions of high temperatures and high-speed rotation.

WHAT IS CLAIMED IS:

1. A fretting resisting roller bearing comprised of a plurality of rolling elements held between inner and outer races with a cage interposed therebetween, characterized in that the oil film of lubricating oil of which the dynamic viscosity at 40°C is 20 to 150 $mm^2/2$ is formed on the raceway surfaces of the inner and outer races, the cage and the rolling elements and grease is enclosed.

2. A fretting resisting roller bearing according to claim 1, wherein said inner and outer races are made of steel and said roller element is made of ceramics.

3. A fretting resisting roller bearing according to claim 1, wherein said inner and outer races are made of steel and said roller element is made of super-hard alloy.

ABSTRACT OF THE DISCLOSURE

This invention relates to a fretting-resisting roller bearing of which the various characteristics are not adversely affected and which achieves a higher temperature and a higher speed as well as a longer life. In a roller bearing comprised of a plurality of rolling elements held between inner and outer races with a cage interposed therebetween, the oil film of lubricating oil of which the dynamic viscosity at 40°C is 20 to 150 mm^2/s is formed on the raceway surfaces of the inner and outer races, the cage and the rolling elements and grease is enclosed.

FIG. 1

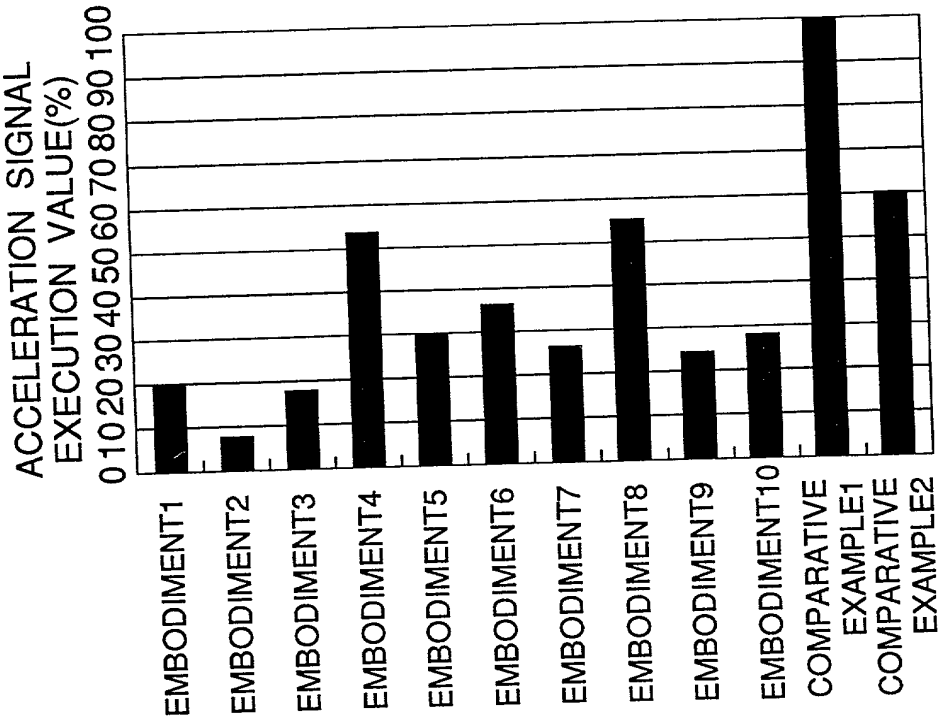
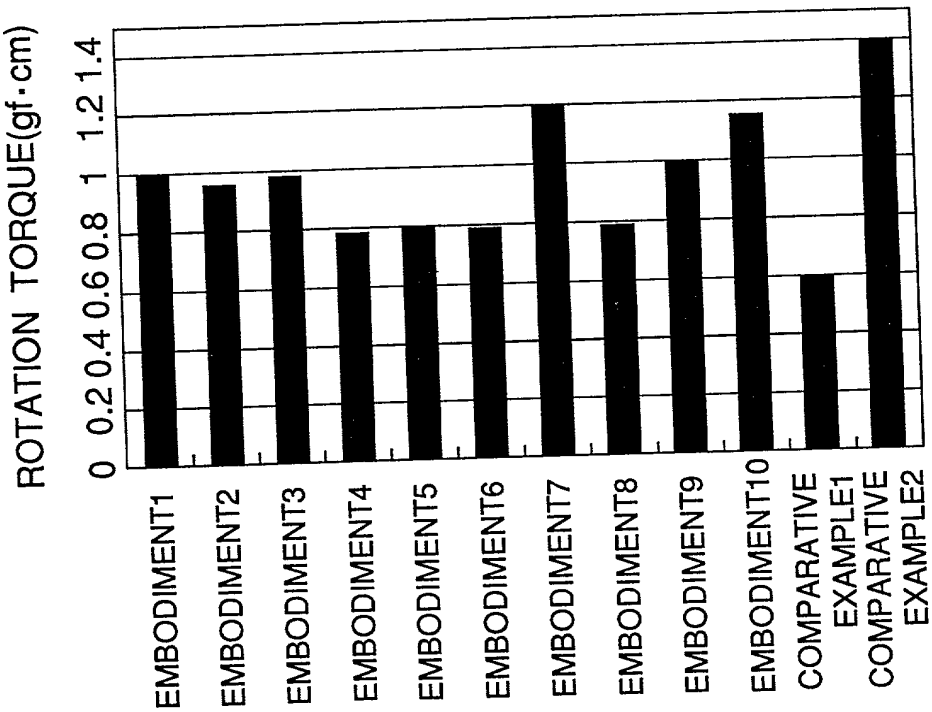

ACCELERATION SIGNAL EXECUTION VALUE(%)
0 10 20 30 40 50 60 70 80 90 100
EMBODIMENT1
EMBODIMENT2
EMBODIMENT3
EMBODIMENT4
EMBODIMENT5
EMBODIMENT6
EMBODIMENT7
EMBODIMENT8
EMBODIMENT9
EMBODIMENT10
COMPARATIVE EXAMPLE1
COMPARATIVE EXAMPLE2

FIG. 2


ROTATION TORQUE(gf·cm)
0 0.2 0.4 0.6 0.8 1 1.2 1.4
EMBODIMENT1
EMBODIMENT2
EMBODIMENT3
EMBODIMENT4
EMBODIMENT5
EMBODIMENT6
EMBODIMENT7
EMBODIMENT8
EMBODIMENT9
EMBODIMENT10
COMPARATIVE EXAMPLE1
COMPARATIVE EXAMPLE2